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ANNEXES TO THE
INTERNATIONAL PRELIMINARY
EXAMINATION REPORT

Reply to Written Opinion of 28.06.04

PCT/CH2002/000349

ANNEX B - REPLACEMENT PAGES 1-3A OF THE DESCRIPTION

(replacement page 1 based on amended p. 1, line 1-14 in PCT/CH2002/000349)

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CATHETERIZATION METHOD AND SYSTEM

5 FIELD OF INVENTION

The present invention relates to a method and system for cardiac catheterization for controlling the displacement of a catheter with respect to the heart of a patient and correcting any undesirable deviation of the catheter tip.

BACKGROUND OF INVENTION

10 Conventional catheterizations controlled by fluoroscopy are generally performed in hospitals, require complex X-ray equipment installed in a particular hospital facility such as a catheterization laboratory or radiology department and must be carried out by specially qualified physicians trained in catheterization procedures. Consequently, these conditions cannot be met in emergencies when the equipment and trained personnel required for catheterization are not readily available.

15 However, in many cases where there is an urgent need for catheterization, the rapid transfer of severely ill patients to a suitably equipped location can be quite problematic and may entail serious risks, even in the case of in-hospital interventions. The transfer of a patient to the next suitably equipped hospital usually takes some time and could affect the patient's chances of survival.

U.S. Pat. No. 6,370,412 relates to a method and apparatus for guiding ablative therapy of abnormal biological electrical excitation by placing passive and active electrodes in or on the body of a patient and electrical energy is delivered to the active electrode(s) to determine the relative locations of the electrical source and the active electrode. It thus relates to a method of cardiac catheterization for guiding a catheter via signals resulting from the cardiac activity of the patient.

W0 99/45994 relates to a remote control catheterization system including a propelling device, which controllably inserts a flexible elongate probe into the body of a patient. A control console, in communication with the propelling device, includes user controls, which are operated by a user of the system remote from the patient to control insertion of the probe into the body by the propelling device. The described remote control catheterization system comprises a fluoroscope for imaging the displacement of the catheter with respect to the heart of a patient.

30 U.S. Pat. No. 6,083,170 relates to a self-aligning catheter having a distal end preferably for insertion through physiological tissue. The catheter includes a sensor that generates signals indicative of a characteristic of the tissue in a vicinity of the probe, and an alignment mechanism, which deflects the distal end of the catheter in response to the signals delivered by the sensor. The signals may be indicative of an obstruction in the lumen in the tissue or of the direction of a clear channel in the lumen.

35 U.S. Pat. No. 5,492,131 relates to a servo-catheter guided by directional control inside a body passage by a servo-type system, which includes a sensor to transmit position, orientation or velocity information to a microprocessor that is typically programmed with an error detection algorithm, and a motion control system.

ANNEX B - REPLACEMENT PAGES 1-3A OF THE DESCRIPTION

(replacement page 2 based on p. 1, line 15 to p. 2, line 11 in PCT/CH2002/000349)

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U.S. Pat. No. 5,391,199 relates to catheterization using fluoroscopy imaging to show the progress 5 of a catheter through a patient's body.

U.S. Pat. No. 6,246,898 relates to a method for carrying out a catheterization by using a 3-D tracking and imaging system that may be configured as a catheter guidance system.

A system for externally locating a catheter described in U.S. Patents No. 4,173,228, No. 5,425,367 and No. 5,645,065 comprises an external probe for locating a catheter tip having an inductive coil for 10 delivering an induced signal in response to a rotating magnetic field generated by the external probe.

However, in the majority of situations requiring catheterization, the heart's structures are the main targets of interest for intervention and they constitute moving targets with variable coordinates, which can only be determined with a limited degree of accuracy.

Externally positioned 3-D sensors do not allow the intravascular position of the catheter to be 15 ascertained and some degree of control by fluoroscopy is nevertheless necessary.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a compact, portable catheterization system suitable for widespread use to rapidly perform catheterizations in different settings by various types of medical personnel.

20 The present invention enables the advance of a catheter to be effectively monitored by using signals delivered by a mobile sensor to detect any deviation preventing the advance of the catheter. The drawbacks and limitations of various proposed imaging, tracking and mapping techniques proposed are thereby effectively avoided.

The term catheter is generally applied here in its broadest possible sense in connection with the 25 present invention and is meant to include any elongated flexible member such as a cardiac catheter, guide wire, pacemaker lead or the like guided along a blood vessel in accordance with this invention.

Signals delivered by the sensor arranged on the catheter according to the present invention represent impulses associated with the cardiac activity and correspond to an internal cardiogram of a patient, and have thus been called cardiac signals with reference to the invention.

30 The present invention now makes it possible to effectively guide a catheter along a blood vessel by combining a sensor with an electronic unit to enable or interrupt the advance of the catheter.

Said monitoring signals delivered by the sensor are modified by an inversion of the position of the catheter tip and enable any deviation preventing the advance of the catheter to be detected.

The catheter may be provided with any suitable sensor to deliver monitoring signals that are 35 modified by any deviation preventing the advance of the catheter. Such a modification of said signals correspond to an inversion of the catheter tip and may be obtained by a corresponding reversal of the direction of the flow of blood at the catheter tip.

ANNEX B - REPLACEMENT PAGES 1-3A OF THE DESCRIPTION

(replacement page 3 based on p. 2, line 19 to p. 3, line 13 in PCT/CH2002/000349)

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5 A bipolar electrode may be used advantageously to obtain monitoring signals corresponding to a reference voltage to enable the advance of the catheter or to a second voltage to interrupt its advance.

The method of cardiac catheterization according to the invention provides for monitoring the advance of the catheter by providing the catheter with at least one sensor serving to detect any inversion of the catheter tip, to deliver cardiac signals representing an internal cardiogram of the patient and to thereby provide monitoring signals to enable or to interrupt the advance of the catheter 10 in order to return the catheter tip to a position enabling its further advance.

This method of catheterization moreover enables the position of the catheter tip in contact with the wall of the heart cavity to be verified by creating impulses at the tip of the catheter and detecting the appearance of corresponding induced signals on a surface cardiogram of the patient.

15 It moreover enables the entry of the catheter tip into the heart atrium of the patient to be readily verified by detecting a significant increase in the amplitude of cardiac signals corresponding to atrial impulses and appearing on said internal cardiogram.

In addition, the passage of the catheter tip from the atrium to the ventricle of the patient may be readily verified by detecting a significant increase in the amplitude of the cardiac signals corresponding to ventricular impulses and appearing on said internal cardiogram.

20 The present invention provides a cardiac catheterization system characterized by a catheter provided with at least one sensor that comprises a bipolar electrode and a flow sensor and is adapted to deliver cardiac signals that represent an internal cardiogram of a patient undergoing catheterization and are modified by any deviation of the catheter tip preventing the advance of the catheter, a central processor connected to said sensor via a first filter, a first analog-to-digital converter and a first signal processor, said central processor further being connected to a device for obtaining a surface cardiogram of the patient via a second filter, a second analog-to-digital converter and a second signal processor, said central processor being adapted to deliver a GO signal, a STOP signal and an END signal to respectively enable, interrupt or terminate the advance of the catheter.

Said catheterization system is advantageously provided with a mobile sensor comprising a bipolar 30 electrode adapted to deliver said cardiac signals and to generate impulses.

The invention may be carried out to meet various diagnostic and therapeutic functions with a catheterization system comprising a catheter provided with a bipolar electrode and a flow sensor.

ANNEX B - REPLACEMENT PAGES 1-3A OF THE DESCRIPTION

(replacement page 3A same as p. 3, lines 14-35 in PCT/CH2002/000349)

3A

The invention may be illustrated by the embodiment described below by way of example with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a bipolar electrode on the free end of a catheter.

Fig. 2 illustrates the path of the catheter in a patient undergoing a cardiac catheterization.

Fig. 2a is a schematic view of the heart region of the patient undergoing a cardiac catheterization

10 Fig. 2b to 2d indicate possible deviations of the catheter tip from the catheterization path.

Fig. 3 represents a block diagram of an electronic unit associated with the bipolar electrode.

Fig. 4 illustrates various signals relating to the catheterization.

DESCRIPTION OF PREFERRED EMBODIMENTS

The tip of the catheter C shown in Fig. 1 is provided with a sensor Sm in the form of a bipolar electrode serving to deliver cardiac signals cs representing electrical impulses associated with the cardiac activity of the patient and including a ventricular signal cv and an atrial signal ca corresponding respectively to the ventricular complex and to the atrial wave of an internal cardiogram of a patient undergoing catheterization. The bipolar electrode Sm also enables the emission of electrical impulses in the heart of the patient.

20 Fig. 2 represents points 1 to 4 indicating various positions of the bipolar electrode Sm on the path of the catheter C extending from the femoral vein to the vena cava inferior of a patient and points 5 and 6, 7 respectively indicating positions of the catheter tip in the right atrium and in the right ventricle of the patient's heart. Fig. 2 and 2a further represent the points 2d, 3d and 5d indicating possible deviations of the catheter tip from the required path 1 to 7.

25 A device SCG for measuring a surface-cardiogram, comprising stationary sensors in contact with

(Replacement page 8)

ANNEX A - NEW CLAIMS 1-5

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Claims

5. 1. A method of cardiac catheterization for controlling the displacement of a catheter tip with respect to the heart of a patient and correcting any undesirable deviation of the catheter tip, characterized by:

(a) producing monitoring signals during the advance of the catheter along a blood vessel by providing the catheter (C) with at least one sensor (Sm) adapted to deliver cardiac signals that 10 represent an internal cardiogram of the patient and are modified by any deviation of the catheter tip preventing the advance of the catheter,

(b) comparing said monitoring signals with a reference during the advance of the catheter,

(c) enabling the advance of the catheter when said monitoring signals correspond to said reference and interrupting the advance of the catheter when said monitoring signals deviate from said 15 reference in order to return the catheter tip to a position enabling its advance.

2. The method according to claim 1, characterized by verifying the entry of the catheter tip into the heart atrium of the patient by detecting an increase in the amplitude of cardiac signals corresponding to the atrial impulses appearing on said internal cardiogram of the patient.

3. The method according to claim 2 characterized by verifying the passage of the catheter tip 20 from the atrium to the ventricle of the patient by detecting a significant increase in the amplitude of the cardiac signals corresponding to ventricular impulses that appear on said internal cardiogram of the patient.

4. The method according to claim 3, characterized by verifying the contact of the catheter tip with the wall of the heart cavity by creating impulses at the tip of the catheter and detecting the appearance 25 of corresponding induced signals on a surface cardiogram of the patient.

5. A cardiac catheterization system characterized by:

(a) a catheter (C) provided with at least one sensor (Sm) that comprises a bipolar electrode and a flow sensor and is adapted to deliver cardiac signals that represent an internal cardiogram of a patient undergoing catheterization and are modified by any deviation of the catheter tip preventing the 30 advance of the catheter,

(b) a central processor (CP) connected to said sensor (Sm) via a first filter (F1), a first analog-to-digital converter (A/D1) and a first signal processor (SP1), said central processor (CP) further being connected to a device (SCG) for obtaining a surface cardiogram of the patient via a second filter (F2), a second analog-to-digital converter (A/D2) and a second signal processor (SP2), said central 35 processor (CP) being adapted to deliver a GO signal, a STOP signal and an END signal to respectively enable, interrupt or terminate the advance of the catheter.